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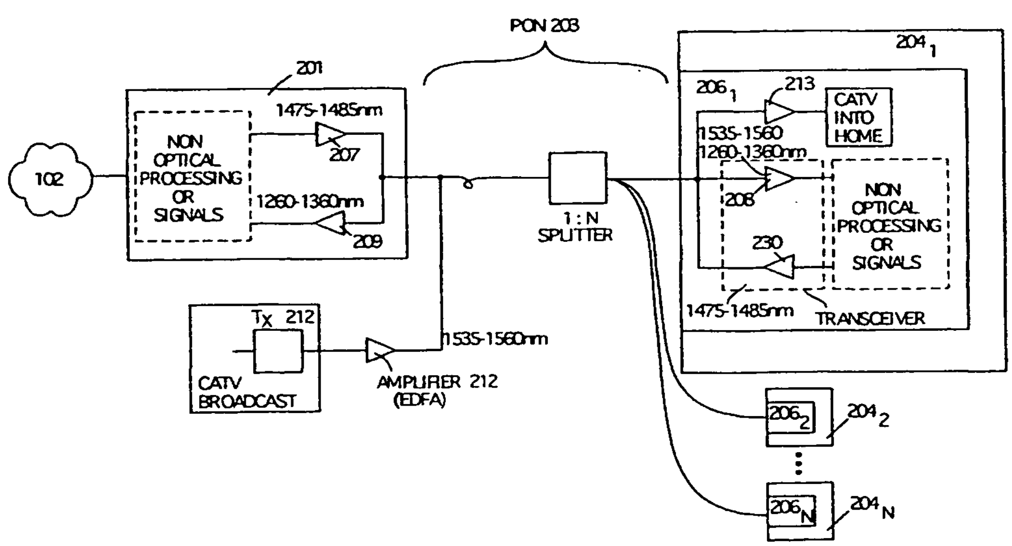
(54) Title: WDM PASSIVE OPTICAL NETWORK WITH BROADCAST OVERLAY



(57) Abstract: In one embodiment, the passive optical network PON (203) that supports bidirectional WDM transmission. The downstream information is broadcasted on the PON (203) on a first wavelength. The upstream information from each network unit is carried on the PON (203) on a second wavelength. A broadcast signal (1535-1560) can be overlayed on the PON (203) on a third wavelength.

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WDM PASSIVE OPTICAL NETWORK WITH BROADCAST OVERLAY

FIELD OF INVENTION

The field of invention relates to fiber optic technology and, more specifically, to fiber optic solutions that may include an interface to a passive optical network.

BACKGROUND OF THE INVENTION

Three network based services currently penetrate the home market: 1) telephone service, 2) cable TV (CATV) service and 3) data service (e.g., internet access service). Unfortunately, at least two different physical connections are typically required to realize these services. For example, a twisted pair telephone wire may be used to transport telephony and Internet traffic and a CATV cable may be used to transport CATV traffic.

Furthermore, each physical connection is typically coupled to a separate network and corresponding service provider. For example, a switched telephone network may be managed by a Local Exchange Carrier (LEC) and a CATV network may be managed by a CATV company. Internet traffic also typically involves an Internet Service Provider (ISP) coupled to the telephone network. The multiple physical connections and multiple service providers may be viewed as a redundant infrastructure that results in inefficient overall delivery of the aforementioned services to the home.

In 1995, several major telecom service providers started an initiative to create standards for a Full Services Access Network (FSAN) that eliminates these inefficiencies. The FSAN specification ITV-T G983 resulted and defined quidelines for an ATM-based passive optical network (PON). The PON employs fiber optic technology. Fiber optic cables allow high bandwidth over long distances and, therefore, serve as an ideal medium for delivering integrated voice, data and video services over a sizable geographic region, such as a suburban neighborhood community.

The FSAN specification sets forth one architecture referred to as Fiber to the Home (FTTH) that uses the PON. Figure 1 illustrates a FTTH architecture as set forth in FSAN Specification ITU-T G.983 (hereinafter "FSAN"). Referring to Figure 1, a resource sharing PON 103 optically couples an optical line unit (OLT) 101 to multiple optical home terminals (OHTs) $106_{1\text{-}N}$ in or near home total $104_{1\text{-}N}$, respectively. In a

downstream direction, the OLT 101 interfaces with (for example) a larger network 102 of a service provider. A single fiber containing all the traffic from the network 102 is communicated by OLT 101 to OHTs 106_{1-N} using PON 103. That is, the OLT 101 distributes the services to each of homes 104_{1-N} via optical signaling techniques across the PON 103.

Since the PON 103 has a shared media topology (i.e., no active device such as a laser or electronic circuit exists within the PON), each of homes 104_{1-N} simultaneously receive/monitor the "downstream" signals (i.e., signals from the OLT 101 to the homes 104_{1-N}). Furthermore, OLT 101 is capable of receiving/monitoring upstream traffic from each of the homes 104_{1-N} via OHTs 106_{1-N} respectively. The downstream traffic may be implemented with 1.5um light while the upstream traffic is transmitted with 1.3um light.

Together, the PON 103, OLT 105 and OHT 106_{1-N} are responsible for converting higher level signals (such as, for example, the dialing sequence of an outgoing phone call from a home) into optical signals, transporting them across the PON 103, and reconverting the optical signals back into corresponding higher level signals at the other end of the PON 103.

According to the FSAN specification, OLT 101 includes a 1.31μm receiver 130 and a 1.5μm transmitter 107, each of which is coupled to PON 103. Any of the OHTs 106_{1-N}, such as, for example, OHT 106_1, comprises a 1.3μm transmitter 108 and a 1.5μm receiver 109. Thus, a system is realized having 1480-1580nm traffic in a downstream (i.e., OLT 105 to OHTs 106_{1-N}) direction and 1260-1360nm traffic in an upstream (i.e., OHTs 106_{1-N} to OLT 101) direction. Since light from the transmitters 107 and 108 travels in the PON 103 and since the receivers 109 and 130 respond to light traveling in the PON 103, both the transmitters 107 and 108 and the receivers 109 and 130 are optically coupled to the PON 103. As such, it may also be said that both the OLT 101 and OHTs 106_{1-N} are optically coupled to the PON 103, since these devices in each are optically coupled to the PON 103.

The PON-based FTTH architecture specified by in the FSAN uses transceivers with comparable power levels in the OHTs 106_{1-N} and OLT 101. For the most part, the FTTH approach of FSAN distributes the optical link costs evenly between the transmission and reception locations. A transmitter's cost is typically measured by the maximum optical power it can launch into the optical fiber, while a receiver's cost is

typically measured by the minimum optical power (also referred to as sensitivity) it can detect from the optical fiber. A modest distance optical link in the FTTH approach of FSAN uses a modest optical launch power transmitter and a modestly receptive receiver with the costs being evenly distributed. Therefore, service providers pay the same amount in both sides of the link for the OLT and OHTs. As those OLTs and OHTs are expensive, it would be desirable to reduce their cost.

Furthermore, the FSAN approach limits the downstream 1540nm signal to a single channel which forces the use of a separate connection (or other high overhead) for video services. The FSAN specification does not provide for an overlay channel. The high overhead associated with the single 1480-1580nm channel approach also raises costs where a simple "broadcast" video channel (i.e., traffic sent only in a downstream direction such as basic CATV service) is needed and the use of a second parallel network may be required.

SUMMARY OF THE INVENTION

A system for communicating via a passive optical network is described. In one embodiment, the system includes a pair of optical terminals communicating using a passive optical network (PON). A first optical terminal is coupled to the PON and has a transceiver that includes a transmitter and a receiver. An amplifier (e.g., EDFA) is also coupled to the PON. A second optical terminal is coupled to the PON. The first and second optical terminals communicate over the PON using asymmetrical optical power levels. The amplifier amplifies information that is to be transmitted on a channel overlayed onto the PON.

In another embodiment, the optical terminal comprises a transceiver, a receiver and a first wavelength division multiplexer (WDM) filter. The transceiver has a transmitter, a receiver and a second WDM filter. The first WDM filter is coupled to the transceiver and the receiver and interfaces an asymmetric optical link to the transceiver. The first WDM filter splits the transmission window of the asymmetric optical link to the optical terminal into two wavelengths to extract an additional channel for reception by the receiver.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements, and in which:

Figure 1 is a prior art FSAN Fiber To The Home (FTTH) architecture.

Figure 2 is one embodiment of an asymmetrical fiber optic architecture having a broadcast overlay.

Figure 3 is one embodiment of an Optical Home Terminal (OHT).

Figure 4 is one embodiment of an optical transceiver module of the OHT of Figure 3.

DETAILED DESCRIPTION

A system for communicating via a passive optical network (PON) is described. In the following description, numerous details are set forth. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form, rather than in detail, in order to avoid obscuring the present invention.

A system set forth herein includes an optical line terminal (OLT) and one or more optical home terminals (OHTs) that transfer information over the PON. As described in more detail below, the communication link between the OLT and at least one OHT is an asymmetric communication link. The system also provides for overlaying a channel onto this communication link.

An optical terminal, such as the OHT, is also described in detail. In one embodiment, the optical terminal comprises a transceiver, a receiver and a first wavelength division multiplexer (WDM) filter. The transceiver has a transmitter, a receiver and a second WDM filter. The first WDM filter is coupled to the transceiver and the receiver and interfaces communications from the PON to the transceiver. The first WDM filter splits the transmission window of the PON into two wavelengths to extract an additional channel for reception by the receiver.

Figure 2 illustrates one embodiment of a system architecture. Referring to Figure 2, the system includes OLT 201 and transmitter 202 optically coupled to passive optical

network (PON) 203. Multiple OHTs, such as OHT 206_{1-N} are optically coupled to PON 203. In one embodiment, each of OLT 201, transmitter 202 and OHTs 206_{1-N} are also physically coupled to PON 203. OLT 201 provides an interface to a service provider sending network-based services to OHTs 206_{1-N} located at the home, small office or other site. Each of the OHTs 206_{1-N} may provide an interface for residential homes for receiving network based services to the home.

The link between the OLT 201 and OHTs 206_{1-N} is an asymmetrical communication link. That is, the long distance fiber optic communication link couples a transmitter in OLT 201 having a large optical launch power into PON 203 which is coupled to a low-cost receiver in one or more of OHTs 206_{1-N} to detect weak optical signals. Therefore, in this case, the transmit end at OLT 201 bears a greater proportion of the costs needed to implement the same modest link. This is advantageous because the system includes only one OLT for multiple OHTs, and the increase in cost associated with the OLT's higher power transmitter (and higher power receiver) is more than offset by the decrease in cost of all the OHTs low power transmitters and receivers.

In one embodiment, the attenuation of the link is greater than 30dB. Thus, for each wavelength, the transmitter/receiver pair sustains a greater than 30dB optical power drop between the transmitter and the receiver that it communicates with (e.g., the transmitter in OLT 201 and the receiver in an OHT, such as OHT 206_1). A part of the greater than 30dB drop stems from the PON 203 which uses a splitter 231 used to spread light signals from the OLT 201 transmitter to each of OHTs 206_{1-N}. Various split ratios may be used (e.g., 1:256, 1:64, 1:32, 1:2, etc.). Each link budget accounts for the optical power loss associated with the specific splitter employed. If higher split ratios are used (e.g., 1:64), the distance between the OLT 201 and OHTs 106_{1-N} should be decreased in comparison to links employing lower split ratios (such as 1:32). Thus split ratio relates to total distance in a manner that may be transparent to the overall link budget.

In one embodiment, OLT 201 comprises a transmitter 207 and receiver 209. Transmitter 207 transmits using optical transmission wavelengths of 1475-1485nm and has a relatively large maximum optical power of +3dBm. Receiver 209 is receptive to optical transmission wavelengths of 1260-1360nm and has a less sophisticated sensitivity of –29dBm. In one embodiment, receiver 209 comprises a burst receiver. In

one embodiment, one or more of OHTs $206_{1\text{-}N}$ comprises a transmitter 208 and receiver 230. Transmitter 208 has a relatively low maximum optical power of -7dBm and transmits at wavelengths of 1260-1360nm. Receiver 230 has a more sophisticated sensitivity of –39dBm and is receptive to optical transmission wavelengths of 1475-1485nm. In alternative embodiments, transmitters and/or receivers of optical powers different than those specified above may be used.

In one embodiment, the system is FSAN compliant. The downstream link uses a spectral window of 100nm for the 1.5μm. That is, the downstream channel may comprise light between 1480nm and 1580um. Similarly, the upstream channel may use light for the 1.3μm. That is, the upstream channel may comprise light anywhere between 1260-1360nm.

In the system of Figure 2, the system splits the downstream channel into two channels. In one embodiment, the two channels are between 1475-1485nm and between 1535-1560nm. The extra channel may be referred to as on overlay channel. Thus, the system comprises three channels: a 1260-1360nm upstream, a 1475-1485nm downstream and a 1535-1560nm downstream channel.

In one embodiment, the 1535-1560nm downstream channel is used to carry a broadcast, such as an analog CATV broadcast, over the PON 203. The channel may be a high speed digital channel. Transmitter 202 (e.g., a linearized transmitter module) is coupled to an EDFA (Erbium Doped fiber Amplifier) 212, which is coupled to PON 203. Transmitter 202 transmits information, using a laser modulator, which EDFA 212 amplifies. In one embodiment, the results of application by EDFA 212 is an optical transmission having +26dBm optical power. Other types of amplifiers may be used.

In OLT 201, the transceiver formed by transmitter 207 and receiver 209 and transmitter 202 interface to PON 203 using wavelength division multiplexing (WDM) multiplexer. In an OHT, such as OHT 206_1, a receiver 213 receives the optical transmission for transmitter 202. In one embodiment, receiver 213 is receptive to optical transmission wavelengths of 1535-1560nm.

A broadband backplane is coupled to OLT 201 and organizes or otherwise encodes and decodes digital traffic as well as separates the digital traffic associated with each service.

A Passive Optical Network (PON) is provided that supports bidirectional WDM point-to-multipoint transmission. The downstream information is broadcasted on a

first wavelength using Time Division Multiplexing (TDM) cell/packet based routing for identification of destination. The upstream information from each network unit is carried on a second wavelength using TDMA cell/packet based burst transmission mode. A broadcast signal can be overlayed on a third wavelength for point to multipoint transmission.

The techniques and apparatus depicted in and described in conjunction with Figure 2 are also applicable to different wavelength schemes (such as 1500nm upstream and 1300nm downstream). Further still, although this description only refers to specific wavelengths, other embodiments comprising different wavelengths may also be used.

Figure 3 is a block diagram of one embodiment of an OHT 206. Referring to Figure 3, an optical connector 324 is coupled to an optical transceiver module 340. The optical transceiver module 340 is coupled to a digital network interface 320, an internal switch 330 and a power management block 370. Digital network interface 320 is also coupled to the power management block 350 and internal switch 330, as well as a line interface module 321. Internal switch 330 is also coupled to an analog CATV broadcast interface 322. Line interface module 321 is also coupled to power management block 350 and multiple service providers.

The optical transceiver module 340 transmits and receives signals to and from PON 203, respectively, using optical connector 324. Optical connector 324 may comprise a single mode fiber connector.

In one embodiment, optical transceiver module 340 comprises a wavelength division multiplexing (WDM) filter module 350, a receiver 313, a transmitter 308, and a receiver 311. Transmitter 308 and receiver 311 form a transceiver that is coupled to WDM filter module 350. Receiver 313 is also coupled to WDM filter module 350.

Transmitter 308 and receiver 311 are coupled to digital network interface 320 and operate in combination as an interface for electrical/optical (E/O) and optical/electrical (O/E) conversion between optical digital traffic and electrical digital traffic. Transmitter 308 receives optical digital traffic from digital network interface 320 and transmits it upstream to OLT 201, via PON 203. Receiver 311 receives optical digital traffic from OLT 201, via PON 203, and sends it to digital network interface 320.

In one embodiment, transceiver 308 is a 1.3 µm burst transmitter (that transmits using an optical transmission wavelength of 1310nm) and receiver 311 is a 1480nm receiver (that receives in a 1480nm window). Transmitter 308 may comprise any light

source. In one embodiment, associated with transmitter 308 is a LASER and a modulator (also referred to as a driver) for the LASER. Receiver 311 may comprises any typically available receiver. Receiver 311 may comprise a burst receiver. In one embodiment, receiver 311 is a photodetecting device (e.g., a PIN photodiode, APD, etc.) and an amplifier.

Receiver 313 receives a broadcast or other channel from PON 203 which is overlayed onto the asymmetric link between OLT 201 and OHT 206. In one embodiment, receiver 313 is a 1550nm receiver (that receives in a 1550 nm window), although receiver 313 may comprises any linear receiver. Receiver 313 may be associated with a photodetecting device (e.g., a PIN photodiode, APD, etc.) and an amplifier.

In one embodiment, the broadcast channel overlayed on the asymmetric link between OLT 201 and OHT 206 comprises an analog cable television (CATV) channel. Receiver 313 provides the received analog broadcast signal to the CATV broadcast interface 322 via internal switch 330. Switch 330 controls access to CATV broadcast services and is driven by digital network interface 320. Switch 330 is not necessary when access to the CATV broadcast service does not need to be controlled.

Digital network interface 320 is responsible for formatting both upstream and downstream digital traffic. In one embodiment, the traffic is all digital traffic except for the analog, 1550nm CATV broadcast signal received by receiver 313. The digital traffic formatting may include any method suitable for organizing and/or encoding upstream digital traffic and also may include any method that successfully reconstructs organized/encoded downstream digital traffic. In one embodiment, formatting methods specified in FSAN are used.

Furthermore, in one embodiment, digital network interface 320 is responsible for separating digital traffic (typically before formatting in the upstream direction and after formatting in the downstream direction) according to their associated services (e.g., telephone/voice and data).

Line interface module 321 is coupled to the digital network interface 320 and presents the user of the OHT 206 with the appropriate service interface. Line interface module 321 receives the separate voice and data generated by digital network interface 320. Line interface module 320 includes one or more interfaces. For example, line interface module 320 may provide interfaces, which may include, but are not limited to,

those set forth in FSAN. As shown, line interface module 320 provides an interface to voice service with a standard plain old telephone system (POTS) interface and also presents data service with either a ATM 25 interface and/or 10Base-T interface.

Further embodiments may provide (in lieu of or in addition to the aforementioned voice or data services) IEEE 1394 Firewire and/or CE Bus data interfaces as well.

Power management block 350 provides power, along with power management, for various components in OHT 206 in a manner well known in the art. Power management block 350 may be coupled to local AC power or one or more batteries.

Figure 4 illustrates one embodiment of the optical transceiver module 340 of OHT 206. Referring to Figure 4, WDM filter module 350 comprises two filters 401 and 402. These filters are referred to herein as WDM filters. WDM filters 401 and 402 extract, from the optical connector 324, each of the wavelength dependent channels in the downstream direction and launch into the optical cable any wavelength dependent channels in the upstream direction.

In one embodiment, WDM filters 401 and 402 comprise interference filters. Filter 401, in conjunction with receiver 313 extract the downstream overlayed channel, which is a 1550nm CATV signal in one embodiment. In an embodiment where receiver 313 comprises a 1550nm PIN photodiode and filter 401 comprises an interference filter, downstream light in the 1535-1560 spectrum reflects off of filter 401 and impinges upon PIN photodiode of receiver 313 (which responds to light within the 1535-1560nm spectrum). Filter 402, in conjunction with receiver 311, extracts the downstream 1480nm data signal. In an embodiment in which receiver 311 comprises a 1310nm PIN photodiode and filter 402 comprises an interference filter, downstream light in the 1475-1485nm spectrum passes through interference filter 401 but reflects off of interference filter 402 and impinges upon the PIN photodiode of receiver 311 (which responds to light in the 1475-1485nm spectrum). In this manner, the 1550nm channel is extracted at the PIN photodiode of receiver 313 and the 1480 channel is extracted at the PIN photodiode of receiver 311.

In an alternative embodiment, filters 401 and 402 may be implemented using integrated waveguide techniques.

Furthermore, upstream 1300nm light is launched into the WDM filter module 350, such that it passes through both filters 401 and 402 and into a fiber optic cable via

optical connector 324. Thus, the WDM filter module 350 is capable of extracting downstream channels while launching upstream channels. One embodiment of the specifications for the WDM filter module embodied in Figure 4 is provided in Table 1.

TABLE 1

Operating Temperature	-40 to +85 °C (Outdoors)
Back Reflection (1480 nm, 1550 nm)	-45 dB, max
Polarization Dependent Loss	0.5 dB max
Directivity from the 1310 nm Tx to the 1550 nm Rx:	-60 dB
Isolation between 1480 nm and 1550 nm signal:	30 dB
Isolation between 1310 nm Tx and 1480 nm Rx:	30 dB

The OLT 205 (referring briefly back to Figure 2) has a similar architecture to the OHT 206 shown in Figures 3 and 4. Specifically, another WDM filter module extracts upstream light from the optical fiber network while launching downstream channels into the fiber optical network.

Whereas many alterations and modifications of the present invention will no doubt become apparent to a person of ordinary skill in the art after having read the foregoing description, it is to be understood that any particular embodiment shown and described by way of illustration is in no way intended to be considered limiting. Therefore, references to details of various embodiments are not intended to limit the scope of the claims which in themselves recite only those features regarded as essential to the invention.

Thus, an optical terminal for communicating via a passive optical network has been described.

CLAIMS

What is claimed is:

1. A system comprising:

a passive optical network (PON);

a first optical terminal, coupled to a first end of the PON, having a transceiver comprising a first transmitter and a first receiver;

an amplifier coupled to a second end of the PON; and

a second optical terminal coupled to the second end of the PON, the first optical terminal and second optical terminal communicating over the PON using an asymmetrical optical power levels, and output of the amplifier being a channel that is overlayed onto the PON.

2. The system defined in Claim 1 wherein the first transmitter transmits in a first transmit window and the output of amplifier being transmitted in a second window.

3. The system defined in Claim 1 wherein the amplifier comprises an erbium-doped fiber amplifier (EDFA).

4. The system defined in Claim 1 wherein the first optical terminal further comprises:

a first wavelength division multiplexer (WDM) filter coupled to the first transmitter and the first receiver;

a second receiver;

a second WDM filter, coupled to the transceiver and the second receiver, for interfacing communication over the PON between the transceiver and the second optical terminal and to split a transmission window of the PON into a pair of transmission windows to extract an additional channel for reception by the second receiver.

5. The optical terminal defined in Claim 4 wherein the transmission window is in an erbium-doped fiber amplifier (EDFA) bandwidth.

6. The optical terminal defined in Claim 4 wherein the first receiver comprises a digital receiver and the second receiver comprises an analog receiver.

7. The optical terminal defined in Claim 4 wherein the additional channel comprises a broadcast channel.

8. The optical terminal defined in Claim 7 wherein the broadcast channel comprises cable television channels.

9. The optical terminal defined in Claim 7 wherein the broadcast channel comprises a high speed digital channel.

10. The optical terminal defined in Claim 4 wherein the transmission window comprises wavelengths between 1475 and 1560nm.

11. The optical terminal defined in Claim 4 wherein the transmission window comprises a downstream transmission window.

12. The optimal terminal defined in Claim 4 further comprising:

a digital network interface coupled to the transceiver; and

a line interface coupled to the network interface.

13. The optimal terminal defined in Claim 4 further comprising an optical connector coupled to the integrated optical module.

14. The optical terminal defined in Claim 13 wherein the optical connector comprises a single mode fiber connector.

15. The optical terminal defined in Claim 4 wherein the second receiver comprises a PIN photodiode.

16. The optical terminal defined in Claim 4 wherein the transmitter comprises a LASER and the first receiver comprises a PIN photodiode.

17. The optical terminal defined in Claim 4 wherein the transmitter transmits signals carried at wavelengths between 1260-1360nm, the first receiver detects signals at wavelengths from 1475-1485nm, and the second receiver detects signals at wavelengths from 1535-1560nm.

18. An optical terminal for communicating via a passive optical network (PON), the terminal comprising an integrated optical module having:

a transceiver comprising both a transmitter and a first receiver coupled to a first wavelength division multiplexer (WDM) filter;

a second receiver;

a second WDM filter, coupled to the transceiver and the second receiver, for interfacing communication over the PON to the transceiver and to split a transmission window of the PON to the optical terminal into a pair of transmission windows to extract an additional channel for reception by the second receiver.

19. The optical terminal defined in Claim 18 wherein the transmission window is in an erbium doped fiber amplifier bandwidth.

20. The optical terminal defined in Claim 18 wherein the first receiver comprises a digital receiver and the second receiver comprises an analog receiver.

21. The optical terminal defined in Claim 18 wherein the additional channel comprises a broadcast channel.

22. The optical terminal defined in Claim 21 wherein the broadcast channel comprises cable television channels.

23. The optical terminal defined in Claim 21 wherein the broadcast channel comprises a high speed digital channel.

24. The optical terminal defined in Claim 18 wherein the transmission window comprises wavelengths between 1475 and 1560nm.

25. The optical terminal defined in Claim 18 wherein the transmission window comprises a downstream transmission window.

26. The optimal terminal defined in Claim 18 further comprising:

a digital network interface coupled to the transceiver; and

a line interface coupled to the network interface.

27. The optimal terminal defined in Claim 18 further comprising an optical connector coupled to the integrated optical module.

28. The optical terminal defined in Claim 27 wherein the optical connector comprises a single mode fiber connector.

29. The optical terminal defined in Claim 18 wherein the second receiver comprises a PIN photodiode.

30. The optical terminal defined in Claim 18 wherein the transmitter comprises a LASER and the first receiver comprises a PIN photodiode.

31. The optical terminal defined in Claim 18 wherein the transmitter transmits signals carried at wavelengths between 1260-1360nm, the first receiver detects signals at wavelengths from 1475-1485nm, and the second receiver detects signals at wavelengths from 1535-1560nm.

32. A system comprising:

a optical line terminal;

an optical home terminal having a transceiver comprising both a digital transmitter and a digital receiver coupled to a first wavelength division multiplexer (WDM) filter;

a passive optical network (PON) optically coupling optical line terminal and optical home terminal,

wherein the optical home terminal further comprises:

an analog receiver; and

a second WDM filter, coupled to the transceiver and the analog receiver, for interfacing the PON between the optical line terminal and the transceiver and to split a transmission window of the PON into a pair of transmission windows to extract an additional channel for reception by the analog receiver.

33. The optical terminal defined in Claim 32 wherein the transmission window is in an erbium doped fiber amplifier bandwidth.

34. The optical terminal defined in Claim 32 wherein the additional channel comprises a broadcast channel.

35. The optical terminal defined in Claim 34 wherein the broadcast channel comprises cable television channels.

36. The optical terminal defined in Claim 34 wherein the broadcast channel comprises a high speed digital channel.

37. The optical terminal defined in Claim 32 wherein the transmission window comprises wavelengths between 1475 and 1560nm.

38. The optical terminal defined in Claim 32 wherein the transmission window comprises a downstream transmission window.

39. The optimal terminal defined in Claim 32 further comprising:

a digital network interface coupled to the transceiver; and

a line interface coupled to the network interface.

40. The optimal terminal defined in Claim 32 further comprising an optical connector coupled to the integrated optical module.

41. The optical terminal defined in Claim 32 wherein the optical connector comprises a single mode fiber connector.

42. The optical terminal defined in Claim 32 wherein the analog receiver comprises a PIN photodiode.

43. The optical terminal defined in Claim 32 wherein the digital transmitter comprises a LASER and the digital receiver comprises a PIN photodiode.

44. The optical terminal defined in Claim 32 wherein the digital transmitter transmits signals carried on a wavelengths between 1260-1360nm, the digital receiver

detects signals at wavelengths from 1475-1485nm, and the analog receiver detects signals at wavelengths from 1535-1560nm.

45. The system of claim 32 wherein the passive optical network comprises the passive 1:N splitter.

46. The system defined in Claim 32 wherein the passive optical network comprises a network of cascaded passive optical splitters.

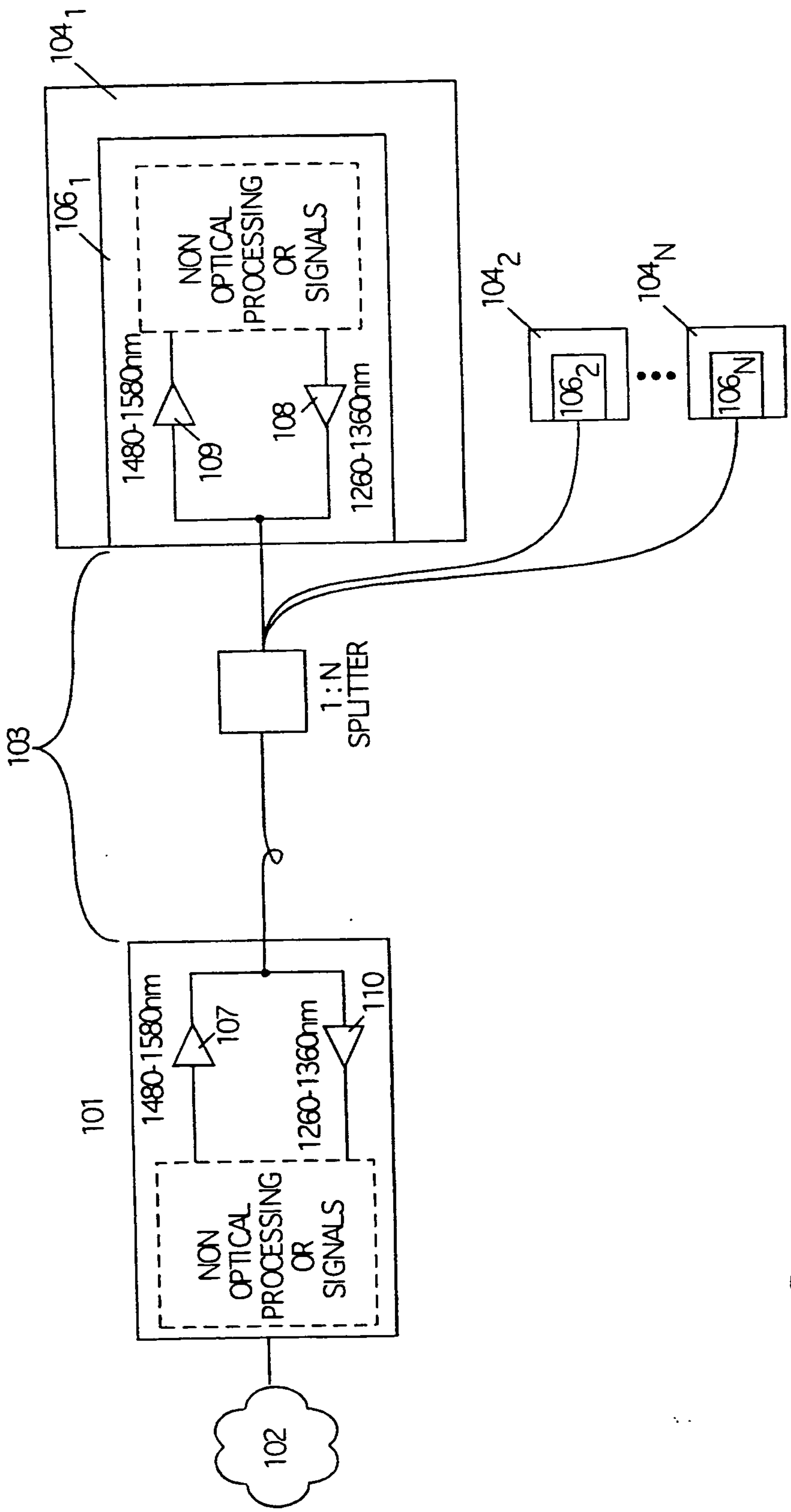
104_1
106_1
NON
OPTICAL
PROCESSING
OR
SIGNALS
1480-1580nm
109
108
1260-1360nm
104_2
106_2
104_N
106_N
1 : N
SPLITTER
103
101
1480-1580nm
107
1260-1360nm
110
NON
OPTICAL
PROCESSING
OR
SIGNALS
102

FIG. 1

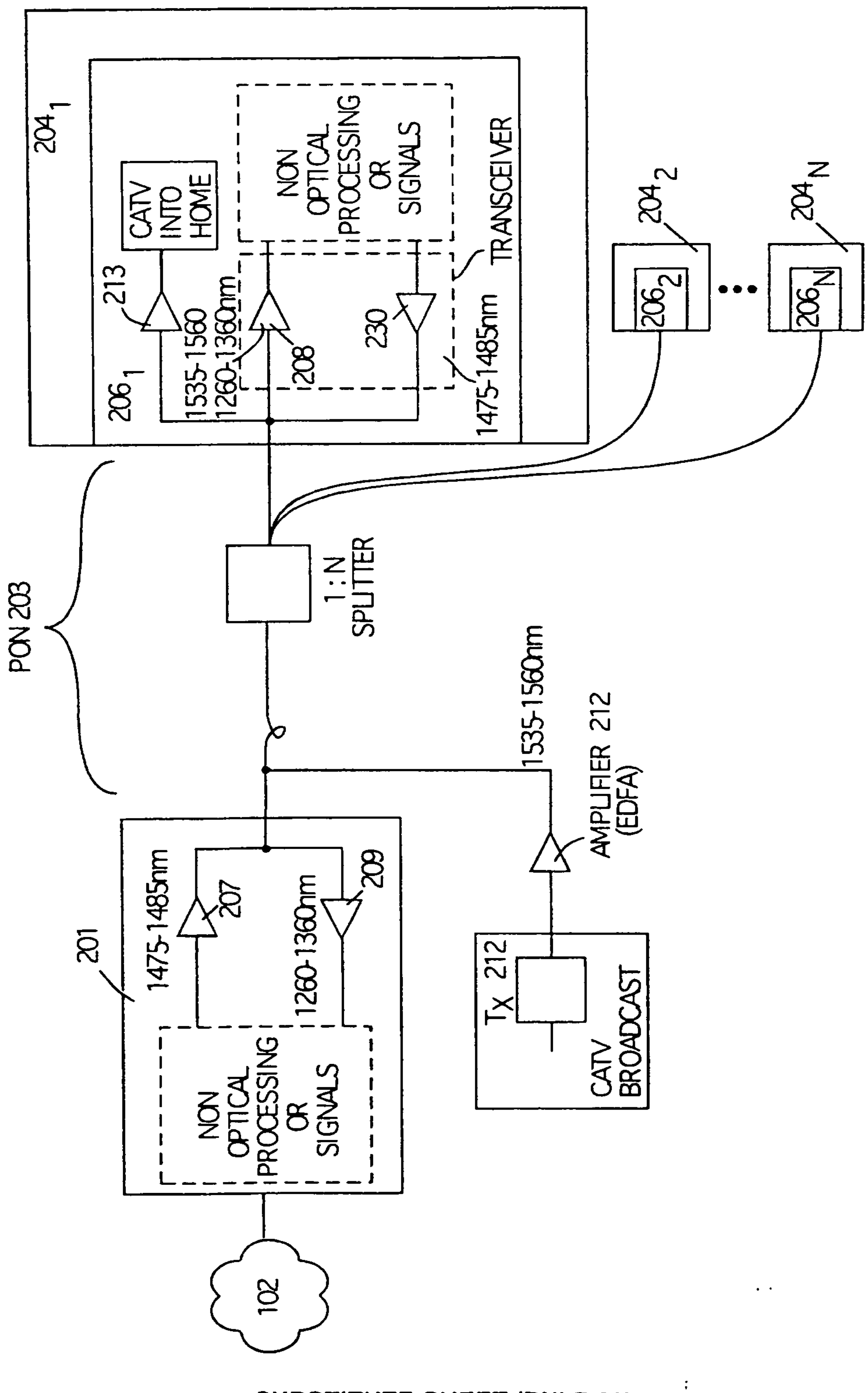
204₁
CATV INTO HOME
NON OPTICAL PROCESSING OR SIGNALS
TRANSCEIVER
213
1535-1560
1260-1360nm
208
230
1475-1485nm
206₁
204₂
206₂
204N
206N
PON 203
1:N SPLITTER
1535-1560nm
AMPLIFIER 212 (EDFA)
201
1475-1485nm
207
209
1260-1360nm
NON OPTICAL PROCESSING OR SIGNALS
Tx 212
CATV BROADCAST
102

FIG. 2

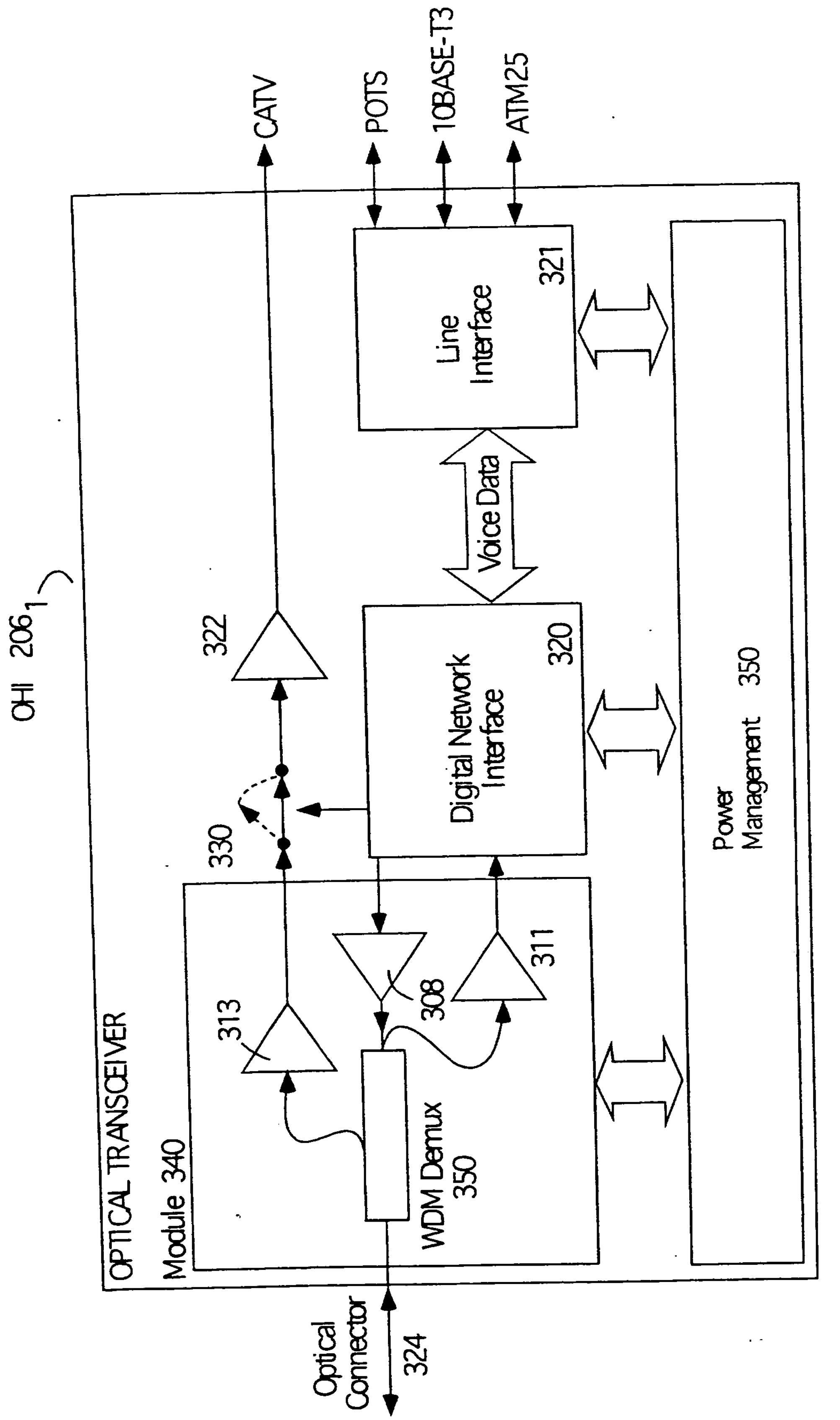
CATV
POTS
10BASE-T3
ATM25
OHI 206₁
Line Interface
321
Voice Data
322
Digital Network Interface
320
Power Management 350
330
OPTICAL TRANSCEIVER
Module 340
313
308
311
WDM Demux 350
Optical Connector
324

FIG. 3

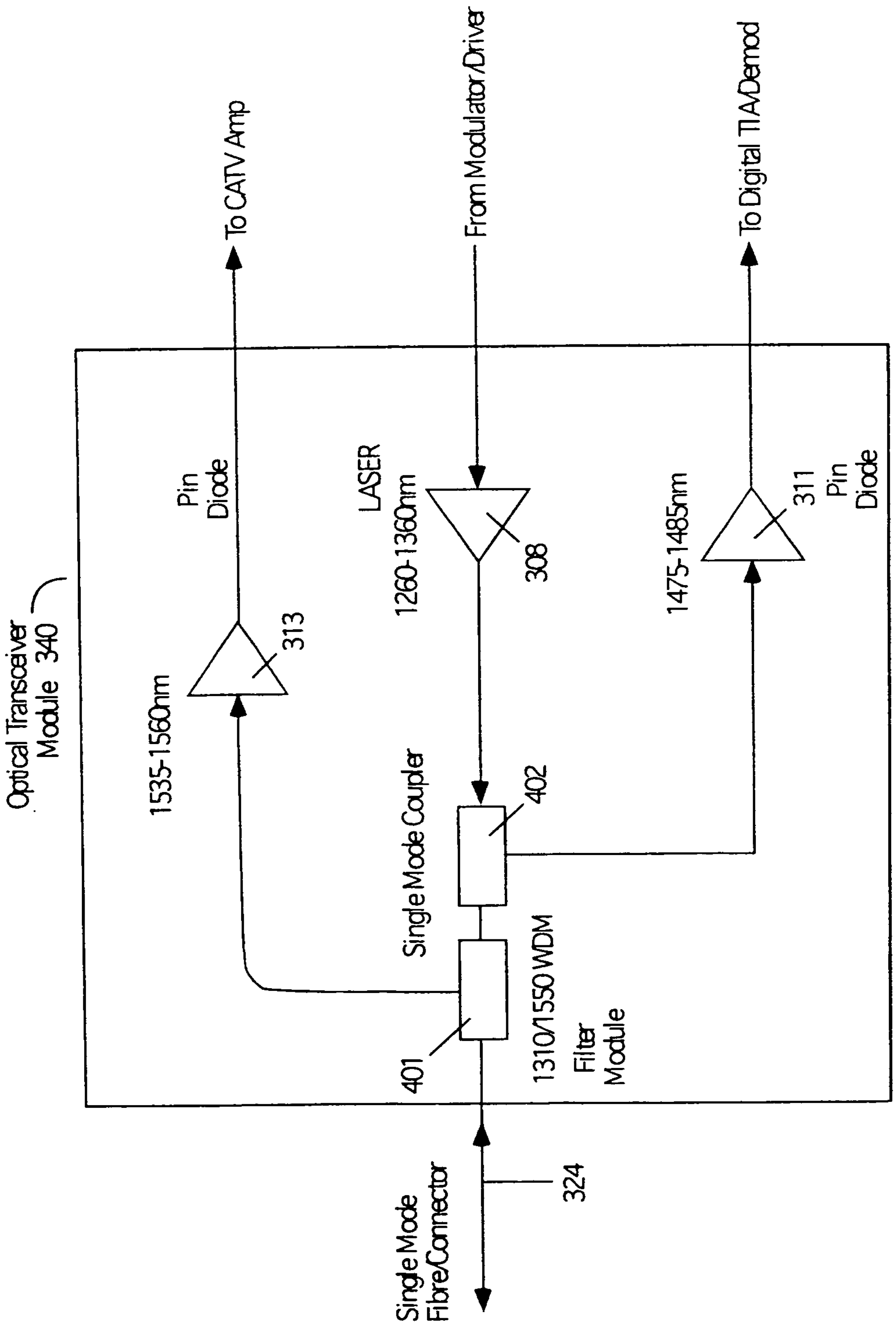
To CATV Amp
From Modulator/Driver
To Digital TIA/Demod
Optical Transceiver Module 340
Pin Diode
LASER
1260-1360nm
308
1475-1485nm
311
Pin Diode
1535-1560nm
313
Single Mode Coupler
402
1310/1550 WDM Filter Module
401
Single Mode Fibre/Connector
324

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/13770

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04B 10/24; H04J 14/02
US CL : 359/125, 114
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 359/125, 114

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST, WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P ------- Y, P	US 5,969,836 A (FOLTZER) 19 October 1999, Figs. 4-6, col. 6, lines 1-67, col. 7, lines 1-67, col. 8, lines 1-67, col. 9, lines 1-67.	1-9, 11-16, 18-23, 25-30, 32-36, 38-43, and 45-46 ------------- 10, 17,, 24, 31, 37, and 44
Y	US 5,694,234 A (DARCIE et al) 02 December 1997, col. 2, lines 40-67, cols. 3-8 , lines 1-67.	1-46

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search 13 JULY 2000	Date of mailing of the international search report 23 AUG 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HUY VU James R. Matthews Telephone No. (703) 305-3900

Form PCT/ISA/210 (second sheet) (July 1998)*